Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

STT03-01 会場:102A 時間:5 月 23 日 09:20-09:35

無人ヘリコプターを利用した樽前山の空中磁気測量
Aeromagnetic survey using an unmanned autonomous helicopter over Tarumae volcano

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1. Introduction

Recently, a remote measurement technique using an unmanned autonomous helicopter is being developed (e.g. Kaneko et al., 2010). Further improvement of suitable instrumentation and operation techniques are, however, necessary for the application to volcanic fields. Hokkaido Regional Development Bureau (HRDB) has similar type of helicopters for the purpose of disaster survey in hazardous zones at an emergency. The authors and HRDB performed a field experiment by using the helicopter over the summit atrio of Tarumae volcano in 2011. Aerial imaging, experimental installation and collection of a seismometer unit, and an aeromagnetic survey were conducted in the fieldwork. We report the results of the aeromagnetic survey, which was the first low-altitude, dense magnetic survey for Tarumae.

2. Measurements results and data processing

The aeromagnetic survey was performed on September 27, 2011 over the summit atrio. The unmanned helicopter (YAMAHA RMAX-G1) was used as a platform with the aid of real-time differential GPS navigation. Magnetic field was recorded in the Geometrics G858 optical-pumping magnetometer at 10 Hz sampling. Differential magnetic field was obtained taking the simple subtraction of the field at the grounded reference station to reduce the magnetic variations of upper-atmospheric origins. In this study, we inverted the magnetic anomaly map into a non-uniform magnetization model using the code of Kaneko et al. (2010) with a small modification. We modeled the topography-related anomalies by using the 10m-mesh DEM which was provided Geospatial Information Authority of Japan (GSI). Non-uniform distribution of magnetization was modeled as an ensemble of vertical prisms of 100 x 100 m size. In the inversion, we evaluated the objective function as the sum of the L2 norm of the difference between modeled and measured fields, and the norm of the deviation magnetization. We here did not fix a priori the DC component of the magnetic anomaly. We performed the inversion for several values of the DC offset to obtain the optimized se t of model parameters which minimizes the ABIC.

3. Modeling result and discussion

We obtained an averaged magnetization as 5.3 A/m. The summit lava dome showed the magnetization of 3-6 A/m. Meanwhile, relatively small magnetization of 2-4 A/m was estimated at the southeastern part of the dome (which is called 'crater A') and the areas around Nishiyama and Higashiyama mounds at the crater rim. In contrast, northwestern part of the atrio showed relatively strong magnetization (5-8 A/m) compared to the dome itself. These results are consistent with the rough estimation by Sakuma and Murase (1956) based on the magnetic inclination anomaly by using a uniformly magnetized ellipsoid, in which magnetization of the dome and the edifice is estimated as 6-8 A/m and 2-3 A/m, respectively. Such variability may be attributed to the difference in magnetization between blocky lava and pyroclastic deposits, as well as to chemical demagnetization due to persistent fumarolic activity at several vents.

From the viewpoint of an aeromagnetic survey, high positioning repeatability is one of the most advantageous features of such an unmanned autonomous helicopter. Optimized operation of the system would enable us to detect temporal changes associated with volcanic activity in the future.

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Keywords: geomagnetic field, Tarumae Volcano, unmanned helicopter, magnetic total force

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航空重力測定における効果的な鉛直加速度補正
Effective vertical acceleration correction in airborne gravity measurements

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日本ではヘリコプターを用いた独自の航空重力測定システムの開発が進められてきた。GPS の利用を除く全システムの国産化が図られ，ヘリコプター搭載型重力計 SEGAWA Model が製作された。SEGAWA Model は，往復残差平均約 1.6mGal という，高水準の再現性をもっている。しかしながら，最も補正量の大きな鉛直加速度補正の最適化，水平加速度補正，フィルタ処理法については，まだ改善の余地が残っている。そこで，これらのデータ処理法について考察を行い，データ品質のさらなる向上を目指していく必要がある。

本研究では，航空重力測定後に行われる補正計算のうち，最も大きな補正量である機体鉛直加速度補正の補正方法について行った考察を報告する。考察した事項は，　重力計から出力される 0.1 秒データを 1 秒データに変換する際に，GPS から推定される機体鉛直加速度 (1 秒データ) と最も高い相関をもつように，データ変換開始時刻を変更する。さらに，　重力計出力データのシグナルレベルと，GPS から推定される機体鉛直加速度のシグナルレベルを揃えてから種々の補正計算を行う。　の考察の結果，2000 年 4 月 27 日のフライトについては，データ変換開始点を-0.8 秒ずらしてやることで，従来の手法によるものと比べて，往復残差平均が 1.2 mGal 改善されることが示された。また，　の考察の結果，従来の手法で採用されていたフィルタ幅を，データの品質を著しく落とすことなく，50 秒程度短くできることが示された。

キーワード: 航空重力測定, ヘリコプター航空重力測定, 鉛直加速度補正
Keywords: air-borne gravity measurement, helicopter-borne gravity measurement system, vertical acceleration correction

Japan Geoscience Union Meeting 2012
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STT03-03 会場:102A 時間:5 月 23 日 09:50-10:15

Airborne electromagnetic investigation of the freshwater potential in northern Sumatra after the Tsunami of 2004

Airborne electromagnetic investigation of the freshwater potential in northern Sumatra after the Tsunami of 2004

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The earthquake at the west coast of northern Sumatra, Indonesia, and the tsunami of 2004 caused the loss of life of a huge number of people and the destruction of houses, basic infrastructure and public facilities. With the tsunami large scale saltwater intrusions crept over the coastal regions and destroyed thousands of shallow water wells. The supply of a sufficient amount of potable water in all populated areas was complicated as many water pipes were broken by the earthquake and a huge number of dug wells were unusable. Many new drillings were not successful in finding potable water due to the lack of information about local hydrogeological conditions. Therefore, the Indonesian and German governments set up a project dedicated to re-install the public life of the people living in the coastal regions of northern Sumatra. The focal point of this ”HELicopter Project ACEH” (HELP ACEH) was water assessment along the shorelines of Aceh. In order to get a fast overview on the remaining freshwater resources and to assist the Indonesian authorities as well as numerous aid organisations in finding suitable locations for drilling new water wells three helicopter-borne surveys including electromagnetics, magnetics and gamma-ray spectrometry were conducted by the airborne group of the German Federal Institute for Geosciences and Natural Resources (BGR) from August to November 2005 (Siemon and Steuer, 2011).

As the mineralisation of water correlates with its electrical conductivity and therefore freshwater and saltwater can be distinguished in general, it was hoped that electromagnetic data would reveal freshwater resources not destroyed by the tsunami, particularly close to the populated coastal areas. The target areas were the city of Banda Aceh with the district of Aceh Besar on the north coast and the area on the west coast between the towns of Calang and Meulaboh in the district of Aceh Barat (Siemon et al., 2007). In addition to that, Coca-Cola Foundation Indonesia (CCFI) funded a further survey on the north-east coast around the town of Sigli in the district of Aceh Pidie (Steuer et al., 2008).

The electromagnetic surveys revealed several potential freshwater resources and areas of saltwater occurrences were mapped in detail. Many requests by aid organisations for information on the local geological and hydrogeological conditions for planned water wells were evaluated and could be successfully answered in most cases. Close to the coasts, however, the investigation depth of the HEM system was constrained due to highly conductive near-surface saltwater and, thus, ground-based time-domain electromagnetic measurements were necessary to reveal deeper coastal freshwater resources. The combination of airborne and ground-based electromagnetic techniques together with a hydrogeological reconnaissance survey increased the efficiency to estimate the freshwater potential. The airborne geophysical surveys helped to close the gaps between task-force measures and long-term planning as well as between spatial surface mapping and local borehole data. Particularly airborne electromagnetics proved to be a very efficient tool to supply hydrogeological baseline data for rehabilitation programs.

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Steuer, A., Siemon, B. and Eberle, D. (2008): Airborne and Ground-based Electromagnetic Investigations of the Freshwater Potential in the Tsunami-hit Area Sigli, Northern Sumatra. Journal of Environmental and Engineering Geophysics, 13(1): 39-48.

キーワード: helicopter-borne electromagnetics, electromagnetics, tsunami, groundwater, saltwater intusion

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Keywords: helicopter-borne electromagnetics, electromagnetics, tsunami, groundwater, saltwater intusion

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STT03-04 会場:102A 時間:5 月 23 日 10:15-10:30

地表ソース型空中電磁探査法の沿岸域への適用性－九十九里と淡路島北西部の比較－
Applicability of grounded-source AEM to coastal areas: Comparison between Kujukuri and Awaji Island cases

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Understanding geological and hydrogeological characteristics in coastal areas is vital because they are the places where most people live and work. Especially, it is important to delineate underground distribution of fresh and saline waters to maintain sustainable development in coastal areas and also for siting of geological disposal of nuclear wastes. As for the latter case, it is desirable to increase the depth of investigation to at least 300 m. To this end, a grounded-source airborne electromagnetics (AEM) is more suitable than conventional AEM. Firstly we applied GREATEM, a type of grounded-source AEM, to an alluvial plain, Kujukuri, where sedimentary rocks and shallow water prevail. The results were remarkable in that a reliable resistivity structure was obtained to a depth of 300-350 m both on land and offshore and low resistivity structures prevail both on land and offshore. We then applied the GREATEM method to northwestern Awaji Island, where granitic rocks crop out onshore. From this survey, we obtained underground resistivity structures to a depth of 1 km onshore and to a depth of 500 m offshore. The results were feasible in that onshore resistivity is much higher than offshore but were not acceptable in that the absolute resistivity value onshore was much lower than the true one. To circumvent this problem, a 3 D inversion technique is currently under development.

キーワード: 空中電磁探査, 沿岸域, 九十九里, 淡路島
Keywords: airborne electromagnetics, coastal area, Kujukuri, Awaji Island

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CONDUCTIVITY RESOLUTION BY VARIOUS HELICOPTER BORNE TEM SYSTEMS

CONDUCTIVITY RESOLUTION BY VARIOUS HELICOPTER BORNE TEM SYSTEMS

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The helicopter borne TEM (HTEM) survey technology is fast, effective, and in true sense a technology of the 21st Century as its genre and wide-ranging applications have increased exponentially since the year 2000. Most of the HTEM systems comprise a large transmitter loop source and a small receiver coil located concentrically or at a point above the transmitter loop that is flown below the helicopter. A couple of exceptional systems are GREATEM and FLAIRTEM that respectively employ a grounded cable and a large loop on ground as transmitters. Contemporary HTEM systems employ a wide variety of primary pulse shapes and transmitter moments to stimulate the subsurface in order to elicit response of geological targets. Frequency contents of these pulses determine the nature of decay response of various types of conducting terrains ranging from highly resistive Archaean granitic gneisses to highly conducting coastal regions with saline water. Numerical modeling is carried out to particularly examine and compare the dB/dt response of these terrains as seen and distinguished by various HTEM systems flying airborne transmitting loops (FLTx) and the GREATEM (GRTx) system. For FLTx systems we have also computed the response considering an ideal rectangular pulse for the purpose of comparison. It is found that the HTEM systems employing rectangular pulses yield fastest decaying transient response and provide the best conductivity discrimination among the FLTx systems. The next to follow are the systems that employ trapezoidal pulses. In this case the decay rate is somewhat slower and the conductivity discrimination is reduced slightly. Similar behavior is observed for the HTEM systems employing sinusoidal and triangular pulses with the latter showing the slowest decay rate and the least discrimination capability. It may also be noted here that slower decay rates also imply that as compared to the HTEM systems employing rectangular pulses, those employing trapezoidal, sinusoidal and triangular pulses see the same geological terrain as increasingly more conducting. Computations for the GRTx system reveal that for highly resistive terrains the decay rates for the FLTx and GRTx are found to be comparable. However, for increasing terrain conductivity, the decay rates for the GRTx slow down considerably and are distinctly separate for various conductivities. Thus the GRTx system provides much better conductivity discrimination as compared to various FLTx systems. The results underscore the advantage of GRTx system that uses the galvanic stimulation of the ground at a fixed spatial location in comparison to the FLTx systems that employ a flying transmitter loop in inductive mode with continuously varying location.

キーワード: AEM
Keywords: AEM

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Airborne Gamma-Ray Spectrometry Surveys in Austria - An Overview

Airborne Gamma-Ray Spectrometry Surveys in Austria - An Overview

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The Geological Survey of Austria (GBA), Department of Geophysics, has been conducting airborne geophysical surveys since the beginning of the Nineteen-Eighties. The current aerogeophysical system includes an airborne gamma-ray spectrometer (AGRS) used for measuring the natural and anthropogenic radioactivity. The AGRS is equipped with eight downward and one upward looking NaI(Tl)-detectors. The AGRS system of the GBA is designed to cover a broad range of applications like geological mapping, geotechnical applications and radiation protection.

The processing of the AGRS-data mainly follows the IAEA guidelines. The data processing includes aircraft and cosmic background correction; radon background correction; Compton correction using stripping ratios calculated from measurements over four transportable calibration-pads and height correction. The parameters to calculate elemental concentrations are determined from repeated flights at different heights over a calibration profile. In order to consider the topography effect, measured concentrations are calculated in respect to the point on the earths surface closest to the detector.

Furthermore, we recently developed a vegetation correction for coniferous forests. The vegetation correction uses the first and the last reflection of the laser altimeter to characterize the vegetation. This vegetation correction has been successfully applied to several survey areas since its introduction.

Besides measuring the abundances of potassium (K), uranium (U) and thorium (Th), the AGRS-system is able to detect Caesium-137 (^{137}Cs). In contrast to K, U and Th, ^{137}Cs is entirely of anthropogenic origin. After the Chernobyl atomic accident in April 1986, radioactive elements were transported through the atmosphere for long distances and distributed over vast areas. Depending on rainfall during this period, which caused a washout from the radioactive cloud to the ground, the soil in the affected regions was contaminated by ^{137}Cs to varying degrees. Although much of the ^{137}Cs content has already decayed (30.17 years half-life), notable amounts can still be detected in Austria.

In 1990 the GBA conducted an airborne survey in an area called Hausruck, located at the northern edge of the Alps. This survey is not only interesting because it achieved our goals in mapping gravel, but because it is also a good example of the benefit of AGRS over non-energy discriminating instrumentation (like Geiger counters). The northern part of the survey area shows a relatively high level of natural radiation. Due to rainfalls on the northern hillsides of the Alps in the time after the Chernobyl accident, there remains an increased concentration of anthropogenic ^{137}Cs in the southern part of the survey area. In this situation the total amount of radiation caused by natural and anthropogenic radiogenic elements is nearly the same in the entire area and only energy discriminating instruments like NaI(Tl)- or Ge(Li)-detectors are able to identify and map the distribution of man-made radiogenic contamination.

In 2009 a multi-sensor airborne geophysical campaign was conducted, which consisted of surveys in Austria and Slovenia. These surveys were designed as test studies for the application of airborne geophysics for landslide investigations. In all of the test sites, minima in the concentrations of ^{137}Cs correlated well with bare surfaces of active landslides, earthflows and zones of higher superficial water flow. One of these survey areas is the test site of Sibratsgfall, a complex of shallow and deep-seated landslides and earthflows. In 2000 the GBA conducted a first survey on this test-site. In 2009 the survey was repeated to monitor changes in geophysical properties of the landslide area. The comparison of the two surveys not only shows minima of ^{137}Cs over the landslide, but also a faster decrease of the ^{137}Cs concentration at the landslide than in the surrounding areas.

キーワード: airborne geophysics, gamma-ray spectrometry
Keywords: airborne geophysics, gamma-ray spectrometry

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航空機モニタリングによる放射性セシウムの沈着量の測定
Radioactive cesium distribution released from Fukushima Daiichi NPP by aerial radiation monitoring

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We measured the ambient dose-rate and the deposition amount of radioactive cesium by using four helicopters in the whole area of East Japan to investigate the influence of the radioactivity that released in the atmosphere due to the disaster of the Fukushima Daiichi NPP (Nuclear Power Plant), Tokyo Electric Power Company (TEPCO), occurred by the East Japan earthquake and tsunami on March 11, 2011. It reports on the measurement technique and the result.

A massive radioactive materials emitted from the NPP was released in the atmosphere due to the disaster and contaminated soils in the wide area in East Japan. Therefore, we have carried out the airborne radiation monitoring (ARM) in the whole area of East Japan, and investigated the influence of the radioactive cesium of the deposition to the ground level.

The ARM can plainly and promptly understand the distribution of the ambient dose-rate and the deposition of radioactive cesium by measuring gamma rays from the urban area to the forest over the wide range. An aerial radiation monitoring has following advantage. (1) The widespread distribution of radionuclides can be measured with short time by less manpower. (2) Descriptive contour maps of the deposition of the radioactive cesium can be depicted. (3) The radioactivity of the mountains and forests can be measured.

We were each equipped with a different measurement system in four helicopters, and they are large-size NaI scintillation detectors (16 x 4 x 2 inches or 16 x 4 x 4 inches) are being used inside/outside of each helicopter in-flight Both counting rates and the pulse-height distribution data (energy spectrum) were detected at each second. We also installed the GPS sensor in the helicopter, and measured the latitude, the longitude, and the altitude of the helicopter at the same time.

The flying altitude from the ground was obtained by subtracting the altitude obtained by the DEM (digital elevation model) data from that of the helicopter. The attenuation coefficient of air was obtained by flying at some altitudes (150 ? 900 m) in above the test-line selected for the comparison with the ground data. Moreover, the conversion coefficient of the ambient dose-rate was calculated by the comparison of the ambient dose-rate measured by an NaI survey-meter with the counting rate at 1 m height evaluated by using the attenuation coefficient.

Furthermore, the deposition amount of radioactive cesium (Cs-134, Cs-137) on the ground was evaluated according to the dose-rate-to-radioactivity conversion coefficient obtained by the result of the in situ Ge measurement on the ground.

We also made maps of the dose-rate and the deposition of radioactive cesium by using the IDW (inverse distance weighted) procedure as an interpolation method of a GIS software.

The map of the ambient dose-rate is shown in Figure 1. It has been understood for the region where the dose-rate is high to extend from the NPP for northwestward, and wide to Gunma Prefecture from the vicinity of Fukushima City in the direction of the southwest. This map is utilized to determine the decontamination area and estimate the variation of contamination areas.

キーワード: 航空機モニタリング, 放射性セシウム, 福島第一原発, 東日本大震災
Keywords: Airborne survey, Radioactive cesium, Fukushima Daiichi NPP, East Japan earthquake

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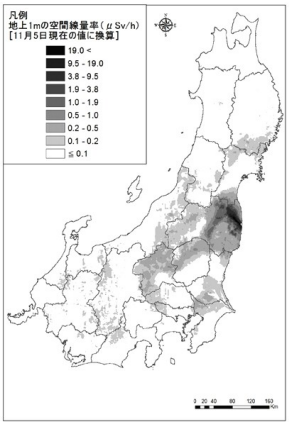

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STT03-08 会場:102A 時間:5 月 23 日 11:55-12:15

除染評価のための気球およびラジコンヘリコプターを用いた空中ガンマ線スペクトロメトリー
Airborne gamma ray spectrometry using balloon and radio controller helicopter for de-contamination evaluation

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Airborne gamma ray spectrometry (AGRS) is the technique used to measure the energy spectrum and intensity of the radiation. AGRS system is newly developed for evaluation of decontamination. Detector packages for airborne spectrometry are made up of 3-inch diameter NaI crystal with a photomultiplier tube. Resolution is about 7%. Peripheral device consist of laser altimeter, GPS, video camera as well as a typical airborne gamma ray device such as pulse height analyzer, etc. 500g KCl reagent bottle is build in near NaI crystal for standard energy of 1,460 keV of K-40. The gamma ray spectrum over the range of 0 to about 2,000 keV is resolved by airborne spectrometers into 1,024 channels. The target nuclides with the emission of gamma rays in range between 0 to about 2,000 keV are natural nuclides (K-40:1460 keV and Bi-214:1765 keV) and man-made nuclides (Cs-137:662 keV), Cs-134:605, 795 keV).

Institute for Rural Engineering has conducted two experimental decontamination of the rice paddy in Iitate Village which has been included in the planned excavation zone with 20-50 mSv/year due to fallout from the Fukushima Dai-ichi Nuclear Power Plant accident; 1) removal of surface soils by fixation agent (RSS-FA) and 2) mixing soils and removal using water (MSRW). Two methods were evaluated by AGRS mounted on balloon and radio controller helicopter (RCH). Area of B site for RSS-FA test is 10,000m^2 within B paddy field (30,000m^2). Area of C site for MSRW test is 10,000m^2 within C paddy field. Survey area of balloon-AGRS is 225,000m^2 included the test site B and C. Survey spacing is 2.5 m. The spectrometer at height 0.05 m in the air was tows by man-power at speed about 3 km/h (0.83 m/s). Measurements before and after decontamination ware carried out on August 3 and 31, 2011, respectively. Survey area of RCH-AGRS is 600,000m^2 included the test site B and C. Flight height and line spacing was 5 m. Data of both survey is sampled once per 10 second. The balloon AGRS could be used with great success to evaluate RSS-FA and MSRW decontamination of paddy fields (Fig.1). It could exactly identify the places: X, Y, and Z where men trampled on the ground surface. RCH-AGRS could show RSS-FA and MSRW decontamination of paddy and revealed that the low radioactive cesium concentration zone to toward the Niita River, which may be caused by radioactive cesium runoff with rain water. RCH-AGRS is an effective tool for monitoring on secondary rework contamination of fallout as well as decontamination.
Keywords: airborne gamma ray spectrometry, decontamination evaluation, Fukushima Dai-ichi Nuclear Power Plant

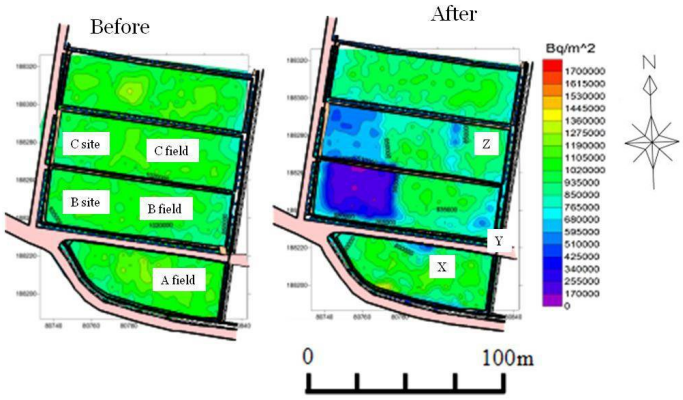

Fig.1 Cs-134 concentration map before and after decontaminations

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STT03-P01 会場:コンベンションホール 時間:5 月 23 日 17:15-18:30

磁気異常から推定した北部九州地域の基盤構造
Magnetic Constraints on the Basement Structure of the Northern Kyushu, Southwestern Japan

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Aeromagnetic anomalies in the northern part of the Kyushu Island, southwestern Japan were reduced onto a smoothed surface of 1,500 m above terrain to compile a new aeromagnetic anomaly map (total magnetic intensity) on a scale of 1:200,000 (Okuma et al., in press). The reduction to the pole anomalies were calculated from total magnetic intensity anomalies as well and compared to the geology (Ozaki et al., in press) and rock magnetic properties (Petrophysical Database of Basement rocks in Japan for the 21st Century (PB-Rock 21), http://riodb02.ibase.aist.go.jp/pb-rock21/index.html) of the area.

In general, the aeromagnetic anomalies seem to be associated with the outcrops of basement rocks such as late Cretaceous granitic rocks and Paleozoic ultramafic rocks. As for magnetic susceptibilities of the late Cretaceous granitic rocks, there are obvious differences among them: older and younger members of late Cretaceous granitic rocks show magnetic susceptibilities equal and higher than 10^{-3} (SI) and lower than 10^{-3} (SI), respectively. Exceptions are older late Cretaceous granitic rocks east of the Tagawa-Kokura fault, which show magnetic susceptibilities lower than 10^{-3} (SI). Magnetic highs lie mainly over the older late Cretaceous granitic rocks and reflect their high magnetic susceptibilities.

The most obvious magnetic anomaly of 400 nT is distributed with a wavelength of about 50km in the E-W direction over the Seburi Mountains southwest of Fukuoka. To better understand the subsurface structure of the area, 3D imaging with source volume minimization (Nakatsuka and Okuma, 2009) was applied to the aeromagnetic anomalies. An E-W cross-section of the 3D magnetic model shows the magnetization high area of 1.0 A/m occupies the Seburi Mountains with a thickness of 20km. According to the seismic activity of the area from 1923 to 2008, major earthquakes with magnitudes larger than 3.0 seem to have occurred only at the boundary of the magnetization high area but not inside. This suggests the magnetization high area indicates the distribution of the granitic body of the Seburi Mountains.

キーワード: 磁気異常, 空中磁気図, 岩石磁気, 三次元イメージング, 九州
Keywords: magnetic anomalies, aeromagnetic anomaly map, rock magnetic property, 3D imaging, Kyushu

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Aeromagnetic 3D subsurface imaging and its application to the data of Otoge Cauldron, Shitara area, Central Japan

Aeromagnetic 3D subsurface imaging and its application to the data of Otoge Cauldron, Shitara area, Central Japan

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In survey methods using potential field such as in aeromagnetics, there is a theoretical difficulty of non-unique source solution for the observation, whereas data includes structural information of wide depth range. In order to overcome this difficulty, the analysis methods with any structural regularization have been developed, and the validity of the strategic regularization would be a primary concern in practice.

We have developed a software of aeromagnetic 3D subsurface imaging, which is applicable to helicopter-borne magnetic (total force) surveys in mountainous regions, and based on the compact regularization to constrain source magnetization succeeding the idea developed by Last and Kubik (1983), Portniaguine and Zhdanov (2002). Our method accepts the surface undulation and variable thickness slicing of model layers, and the regularization criterion of minimum effective source volume is adopted.

The software was first applied to synthetic and geologic models to evaluate its characteristic ability of recovering source structure and to examine the efficiency of the method. In spite of the intrinsic difficulty of the non-unique problem, the results revealed that good recovery of subsurface image can be achieved by a proper choice of trade-off parameter to assure the compactness, and it was proven that the compact regularization is useful to interpret magnetic anomaly data in terms of 3D source configuration.

The helicopter-borne magnetic survey data in the Shitara area was put into analysis by this 3D imaging software. The geology of Shitara area is characterized by middle Miocene Otoge and Shitara igneous complexes, the Otoge Cauldron structure with stock, and post-cauldron intrusions of dike swarms (Otoge cone sheets and Shitara central dike swarm). The 3D imaging analysis of magnetic anomalies revealed the magnetization structure (to the depth of 3000m) of the magma reservoir of Otoge Cauldron, the Otoge cone sheets, and Otoge stock, to be consistent with existing studies from surface geology.

キーワード: aeromagnetic, 3D imaging, compact inversion, source volume minimization, helicopter survey, Otoge Cauldron
Keywords: aeromagnetic, 3D imaging, compact inversion, source volume minimization, helicopter survey, Otoge Cauldron

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移動体用重力計のためのデジタルサーボセンサーの基本性能に関する研究
Performance of digital servo sensor for gravity survey using a carrier

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Modeling ground structure is one of the most important topics for the estimation of seismic hazard these days. Gravity survey is one of exploration methods. We can estimate ground structure by using information of gravity anomaly which comes from heterogeneous density structure of the ground. Generally speaking, there are high correlation between density and velocity structure of the ground. Thus, the gravity survey is comparatively easier than other exploration method to estimate the ground structure, so that it is very suitable for the aspect of the seismic hazard projection.

For the gravity survey, spring-type relative gravimeter is usually used. This type of gravimeter can provide accurate data. However, it is very expensive and difficult to handle. Furthermore, it takes much time to obtain adequate data. From these reasons, data which is required to model ground structure is not so enough in the present time.

Under such background, we began to develop a simple and inexpensive sensor which can measure anomaly on a mobile carrier, such as vehicle, ship, aircraft, and so on. In a case where a gravimeter is used with a mobile carrier, we may survey the gravity over larger area in shorter time than using conventional survey techniques. Generally speaking, for the gravity survey, the gravity should be measured with resolution of 10 micro Gal at least. However, the signal obtained from gravimeter is contaminated by various noises: vibration of a carrier, circuit noise of a system, fluctuation of temperature, and so on.

Thus, we have to develop a sensor, and a method to analyze observed data, which can provide accurate data of gravity under very noisy environment.

We have developed a new sensor with digital feedback system, which has high resolution and large dynamic range. The performance of the sensor is examined in this study. For this purpose, two different types of observations were carried out.

From the static observation in a tunnel, it is found that the sensor can respond to gravity caused by the earth tide. Furthermore, we can say that the algorithm of digital feedback system has room for improvement.

From the observation on a ship, high frequency vibration which has big amplitude makes the gravity blind. If the carrier's vibration is so strong, it is impossible to estimate gravity using simple filtering. However, we can obtain the signal correspond to the gravity from Hilbert Huang Transform (HHT).

Keywords: gravity survey, digital feedback system, Hilbert-Huang transform

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THREE-DIMENSIONAL MODELING STUDY OF SEA EFFECTS ON EM FIELD INDUCTION USING GREATEM SYSTEM
THREE-DIMENSIONAL MODELING STUDY OF SEA EFFECTS ON EM FIELD INDUCTION USING GREATEM SYSTEM

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To understand the sea effects on electromagnetic field (EM) induction at sea-land boundary using GRounded Electrical source Airborne Transient ElectroMgnetics (GREATEM) system, we computed time-domain EM responses for 3D structures applying a 3D EM modeling scheme based on finite difference (FD) staggered rectangular non-uniform grid formulation for the secondary electric field with continuous components of tangential electric and normal magnetic fields (Fomenko and Mogi, 2002).

The 3-D response were calculated by computing secondary EM field originating by 3D anomalies which induce the primary EM field on a horizontal multi-layer structure by a grounded electrical dipole source. Time-domain responses were computed by the sine or cosine transformation from the frequency-domain data. The range of computing in frequency-domain is 10000 to 0.01 Hz and transient time responses were obtained at 0.0001 to 1 sec. The models consisted of two adjacent layers of different conductivity, where the sea is very thin sheet of a perfect conductor placed on top of a uniform half space earth medium. The EM responses are calculated for different models when the grounded electrical source is located at (10, 20 and 300m) of coastline in landward and the uniform half space earth medium resistivities vary from high resistive host rock (100 ohm m) to high conductive host rock 1 ohm m.

The 3D modeling results have shown that, the sea effect on EM field induction at sea-land boundaries using GREATEM system is function in the distance between the ground electrical source and coastline, for example the sea effect EM field induction in case the source is located at 10m or 20m of coastline in landward is higher than the case when the source is located at 300m of coastline in landward. Also the sea effect on EM field induction at sea-land boundary is function in the host rock resistivity, for example in case the host rock resistivity is 100 ohm m the effect of sea on EM field is higher than the case when the host rock resistivity is 10 ohm m.

キーワード: AEM, GREATEM, 3D EM modeling
Keywords: AEM, GREATEM, 3D EM modeling

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地表ソース型空中電磁探査法の沿岸域への適用性－淡路島北西部の例－
Applicability of grounded-source airborne electromagnetics to coastal areas: Northwestern Awaji Island case

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Understanding geological and hydrogeological characteristics in coastal areas is important in many ways and especially for siting of geological disposal of nuclear wastes. We have developed a type of airborne electromagnetics (AEM), called grounded electrical source airborne transient electromagnetics, or GREATEM, in which we have succeeded to increase the depth of investigation from conventional 200 m to 300-350 m in an alluvial coastal plain, Kujukuri, Japan. Here, we present another application of GREATEM to northwestern Awaji Island. Compared to Kujukuri, the northwestern Awaji Island is a rugged mountainous area, and hence much difficult to apply AEM. It is also characterized in that granitic rocks are widely distributed and a distinct fault, the Nojima fault, which was activated in the 1995 Kobe earthquake, lies parallel to the coastal line. Our temporary conclusions are as follows: Although it is difficult to obtain the exact electric resistivity value for granitic basements, remarkable differences exist between onshore and offshore underground resistivities. By applying a slow flight speed of ˜40 km/h, we could obtain offshore underground resistivities to a depth of ˜500 m, which should be the world's deepest investigation depth by AEM.

キーワード: 空中電磁探査, 地層処分, 沿岸域, 淡路島
Keywords: Airborne electromagnetics, Geological disposal, Coastal area, Awaji Island

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福島県の放射性セシウムの土壌汚染エリアにおける無人ヘリコプタを使った遠隔測定
Remote radiation monitoring of radioactive cesium by unmanned helicopters at the soil contaminated area in Fukushima

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By the nuclear disaster of Fukushima Daiichi Nuclear Power Plant (NPP), Tokyo Electric Power Company (TEPCO), caused by the East Japan earthquake and the following tsunami occurred on March 11, 2011, a large amount of radioactive materials was released from the NPP. An emergency radiation monitoring, in order to evaluate the effects of such radiation on the surrounding environment, as well as ground measurements were conducted from the sea and air. As a means of radiation monitoring from the air, aerial monitoring using manned helicopters was conducted in the whole area of East Japan. Although manned helicopters can monitor a large area in a short time, flight at an altitude of 150 m or lower is prohibited by the Aviation Law in Japan. Therefore, it is difficult for a manned helicopter to measure the radiation profile near the ground and to measure the radiation level in a complicated terrain. In recent years, technologies for autonomous unmanned helicopters (AUHs) have been developed and applied to natural disasters. In expectation of the application of the AUHs to aerial radiation monitoring, we had developed a remote radiation monitoring system. Then, we measured the radiation level by using unmanned helicopter in soil contaminated areas by radioactive cesium emitted from the NPP to evaluate ambient dose-rate distribution around the areas and to investigate the decontamination effect by the measurements before and after decontamination treatment. Here, we reports on the measurement technique and the result.

This system we used is mounted a plastic scintillation detector (size: 270 x 300 x 20 mm) on the AUH (RMAX G-1, Yamaha Motor Co., Ltd.), and can fly for the destinations and return by the automatic operation, and the radiation data can be measure during the flight. Radiation data are transmitted immediately with image and position data to the monitoring station on the ground. It is possible to monitor these data on the map of the computer display in the real time. At this time, we have fled the AUH at 30 - 50 m high above the ground in the contaminated areas around the NPP. Furthermore, this system was also installed two GPS sensors on the AUH, and measured the latitude, longitude, and the flying altitude at the same time. The flying altitude from the ground was obtained by subtracting the altitude obtained by the DEM (digital elevation model) data from that of the helicopter. The attenuation coefficient of air was obtained by flying at some altitudes (5 - 50 m) in above the test-line selected for the comparison with the ground data. Moreover, the conversion coefficient of the ambient dose-rate was calculated by the comparison of the ambient dose-rate measured by an NaI survey-meter with the counting rate at 1m height evaluated by using the attenuation coefficient. Finally, we made maps of ambient dose-rare distribution from the analyzed results of radiation by using a GIS software.

In addition, we developed a system using a manual operated unmanned helicopter to fly complex terrain and measure the radiation in narrow areas. In this system, both a CCD camera and a GPS sensor are installed besides a radiation detector using a plastic scintillator, we can measure the radiation, the monitoring position and image in real time.

We present the outline of these systems and the measured results obtained in Fukushima Prefecture.

キーワード: 無人ヘリコプター, エアボーンサーベイ, 放射性セシウム, 福島第 1 原子力発電所事故
Keywords: unmanned helicopters, airborne survey, radioactive cesium, the nuclear disaster of Fukushima Daiichi NPP